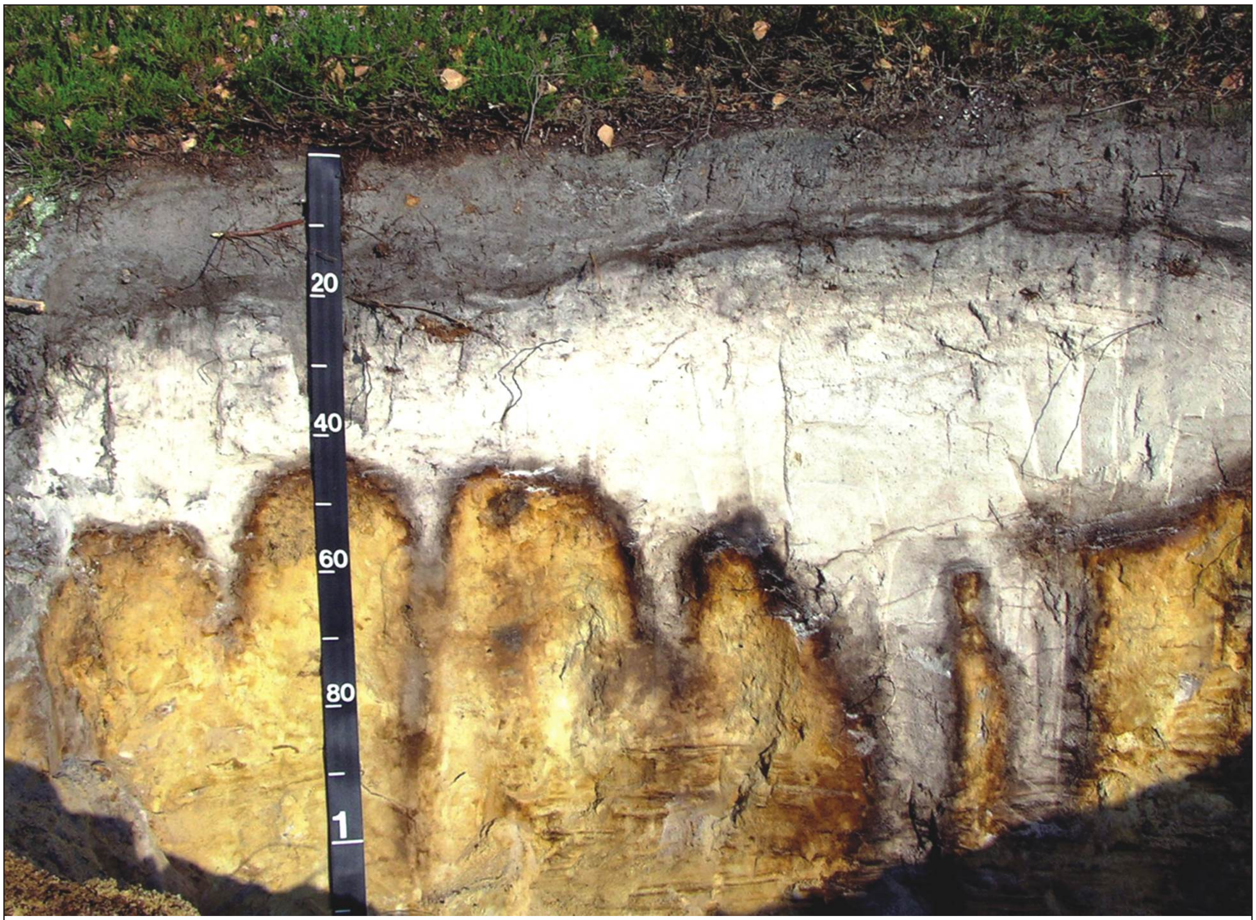

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Effects of Tithonia Green Manure and Water Hyacinth Compost Application on Nutrient Depleted Soil in South-Western Nigeria

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Abstract: The study was conducted to investigate the application effects of *Tithonia diversifolia* (Hemsley) A. Gray) green manure and water hyacinth [(*Eichhornia crassipes*) Mart) Solms] compost on nutrient depleted soil from under an alley cropping system. The study was carried out at the Botany and Microbiology Department, University of Ibadan. Three different soil amendment treatments including control were used in the study. These were applied in sole applications as well as in varying combinations of the different treatments. The organic amendment treatments were compared to natural fallow as unfertilized control in a modified screen house experiment replicated 3 times in a Completely Randomized Design (CRD). The results showed that the application of 250 t ha^{-1} of fresh organic amendments increased the soil N, P, K, Ca, Mg, Cu, Zn, Mn, Fe, nitrate and nitrite compounds, pH and organic C of treated soils (both top and sub soil samples). Varying application rates of 187.5 and 62.5 t ha^{-1} also showed increased nutrient status for all aforementioned nutrient elements relative to the control treatment. Combination of *Tithonia* green manure and water hyacinth compost in the ratio (0.25:0.75 kg) was the most effective in increasing soil nutrient status of all treatments applied. The significance of increase in soil nutrient status of amended soils indicates that local farmers can gainfully substitute use of more expensive chemical fertilizers with these more readily available organic amendment resources.

Key words: Organic amendments, *Tithonia diversifolia*, *Eichhornia crassipes*, soil nutrient status, fertilizers

INTRODUCTION

Soil fertility issues have recently become of mounting interest in tropical Africa. This is due largely to growing need to achieve food security for a rapidly expanding population which has led to intensive exploitation of cropland resources (Hossner and Anthony, 1999). Consequently, this has caused degradation of available soil resources in tropical Africa; with the attendant ecological problems of soil erosion and nutrient leaching posing a serious threat to sustainable food production in this highly populated region.

Efforts at remediating soil fertility over the years have basically been achieved using traditional resources of farmyard manure and crop residues in composted forms as well as use of inorganic fertilizer (Sridhar and Adeoye, 2003). These however have their attendant constraints in the procurement and application as soil fertility improves such as high cost (chemical fertilizers) and relatively low nutritive values (crop residues). One largely overlooked resource available for soil fertility remediation is the use of non-traditional organic materials such as weeds. *Tithonia diversifolia* and water hyacinth (*Eichhornia crassipes*) are common weeds in the tropics generally considered as

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ecological nuisance in land and water areas respectively where they exist. Weeds however, have been recognized to have significant effects on sustainability of soil nutrient resources and yield of agricultural produce (Oyetunji *et al*., 2003).

Tithonia has been extensively researched into as soil fertility improver in several East African countries (Gachengo *et al*., 1999; Jama *et al*., 2000; Nziguheba *et al*., 2002) yet has potential for further exploitation in other parts of tropical Africa. Water hyacinth has also been exploited in several African countries (Abdalla and Abdel, 1969; Kamal and Little, 1970; Bates and Hentges, 1976), yet not much has been documented on its soil improvement capability particularly in West Africa despite its abundant occurrence in freshwater bodies and waterways in the region (Uka and Chukwuka, 2007).

The objective of this present investigation is to find out more about the soil nutrient improvement capacity of these non-traditional organic resources as green manure and compost, as well as comparing their effects to natural fallow system.

MATERIALS AND METHODS

Soil samples were obtained from the Agronomy Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria, located in the forest-savanna transitional zone of tropical West Africa. The soil at the site of collection is classified as an Alfisol. Soil samples were taken from A horizon of soil profile (0-35 cm depth) for top soil samples and from the B horizon (45-60 cm depth) for subsoil samples. The samples were transferred to the Department of Botany and Microbiology, University of Ibadan between March 2 and March 29, 2007. Soil nutrient analysis test before amendments was carried out for soil sample types. Soil pH in water was derived by extraction using standard soil scoop and then reading pH value on pH meter standardized with buffer solution of pH 4.0 and 7.0 (IITA, 1982). Soil organic carbon was determined by the Walkley Black Modified Method, while exchangeable Ca, Mg, K, P, Na, Mn, Cu, Zn and Fe was determined by the Mehlich-3 Extraction procedure (Mehlich, 1984). Total nitrogen, nitrate and nitrite in soil extracts were analyzed by the Technicon AA II method (IITA, 1982).

A modified screen house experiment was used in this study with experimental pots arranged in a Completely Randomized Design (CRD) with three replications. Equal weights (8 kg) of top and sub soil samples were respectively measured into 10 L plastic buckets perforated at their bases. The plastic buckets were labeled A, B, C, D, E and F. Fresh green leaves and tender stems of *Tithonia* and also heap method prepared water hyacinth compost were applied to designate buckets in both sole applications and also varying combinations as stated below:

A : *Tithonia* green manure alone (1 kg)
B : Water hyacinth compost alone (1 kg)
C : *Tithonia* + Water Hyacinth (0.5:0.5 kg)
D : *Tithonia* + Water Hyacinth (0.25:0.75 kg)
E : *Tithonia* + Water Hyacinth (0.75:0.25 kg)
F : Control (natural fallow)

The organic amendments were incorporated into the designated soils in buckets and allowed to decompose over a period of 7 weeks. After this period, samples were taken from respective treated soils and analyzed to determine the extent of nutrient mineralization in the soils.

RESULTS

The nutrient parameters, including macro and micro nutrients, which were analyzed in both top and subsoil samples are shown in the Table 2 and 3. Initial soil analyses for nutrients before addition of amendments are represented in Table 1 for top and subsoil samples respectively. In all soil types, treatments improved exchangeable elements Ca, Mg, K and Na as well as microelements Mn, Fe, Cu and Zn content in soil samples (Table 2, 3). Also, exchangeable acidity and effective cation exchange capacity were improved by the treatments. In general, identified macro and micro elements were increased in both soil types with the treatments. Nutrient values for the various treatments of soil after amendments are presented in the Table 2 and 3 for top and subsoil samples respectively. pH values for both soil sample types, as well as percentage Carbon and Nitrogen content in pre amended and post-amended soils are shown in the Fig. 1-3. Figure 1 showed that *Tithonia* Green Manure (TGM) and the Water Hyacinth Compost (WHC) treatments generally increased the pH of all amended soil types. However, the effect of increased pH is well pronounced in all subsoil treatments. Similarly, percentage organic carbon content (Fig. 2) generally increased in all top and subsoil treatments except for the amended soil types with application of the organic amendments in equal proportion (0.5:0.5 kg). In both soil types, treatment application of TGM and WHC at ratio 0.25:0.75 kg showed remarkable increase in organic carbon content. In the treatment application of ratio 0.75:0.25 kg of the organic amendments, exchangeable elements values recorded least increase as compared to other combination treatments (i.e., 0.5:0.5 and 0.25:0.75 kg) for top soil samples (Table 2). This trend is however reversed in the subsoil samples (Table 3) where this treatment recorded highest increase in exchangeable elements values compared to the other combination treatments. In Fig. 3, there is marked increase in percentage nitrogen content for all soil types with

Table 1: Top and Subsoil Nutrient Analyses before amendment

Soil type	Clay	Silt (%)	Sand	pH (H_2O)	Org. C (%)	Ca	Mg (C mol kg^{-1})	K	Na
Top soil	21.00	12.01	68.03	7.4	3.29	30.81	3.02	1.08	0.59
Sub soil	33.10	10.04	56.90	5.5	2.09	5.14	1.51	0.78	0.73
Soil type	**Exch. acidity**	**ECEC**	**P**	**Zn**	**Cu (ppm)**	**Mn**	**Fe**	**NO_3^-N**	**NH_4^-N**
Top soil	0.17	35.50	55.62	2.66	3.02	230.78	115.92	10.68	28.90
Sub soil	0.17	8.33	23.83	1.61	2.38	79.18	77.55	6.16	11.72

Exch. acidity = Exchangeable Acidity, ECEC = Effective Cation Exchange Capacity

Table 2: Top soil nutrient analysis after amendment with *Tithonia* green manure and water hyacinth compost

Treatments	Ca	Mg (C mol kg^{-1})	K	Na	Exch. acidity	ECEC	Mn	Fe (ppm)	Zn	Cu	P
A [Tith. 1 kg]	53.62	7.54	3.11	1.06	0.43	65.76	266.15	103.28	2.84	3.29	97.43
B [W.H. 1 kg]	49.71	6.86	2.94	1.01	0.39	60.51	271.54	115.69	3.01	3.27	98.56
C [Tith. + W.H 0.5:0.5 kg]	51.93	7.36	3.09	1.28	0.41	65.07	256.81	107.82	2.79	3.36	89.35
D [Tith. + W.H 0.25:0.75 kg]	56.49	7.28	3.17	1.33	0.41	68.07	263.44	105.66	2.83	3.29	91.86
E [Tith. + W.H 0.75:0.25 kg]	48.33	6.91	2.78	0.98	0.38	59.38	269.32	104.43	2.79	3.18	95.57

Exch. acidity = Exchangeable acidity, ECEC = Effective Cation Exchange Capacity, Tith. = *Tithonia* green manure, WH = Water hyacinth compost

Table 3: Sub soil nutrient analysis after amendment with *Tithonia* green manure and water hyacinth compost

Treatments	Ca	Mg (C mol kg^{-1})	K	Na	Exch. acidity	ECEC	Mn	Fe (ppm)	Zn	Cu	P
A [Tith. 1 kg]	26.41	3.67	1.43	0.76	0.29	32.58	153.89	89.36	2.04	2.81	61.50
B [W.H. 1 kg]	26.39	4.05	1.46	0.81	0.31	33.02	149.36	84.67	1.93	2.66	59.83
C [Tith. + W.H 0.5:0.5 kg]	25.58	3.29	1.27	0.83	0.28	31.25	98.97	91.35	1.89	2.74	63.34
D [Tith. + W.H 0.25:0.75 kg]	30.01	3.74	1.29	0.82	0.29	36.15	115.38	87.64	2.07	2.83	62.09
E [Tith. + W.H 0.75:0.25 kg]	26.59	4.01	1.48	0.85	0.30	33.23	152.11	90.14	1.11	2.79	58.66

Exch. acidity = Exchangeable acidity, ECEC = Effective Cation Exchange Capacity, Tith. = *Tithonia* green manure, WH = Water hyacinth compost

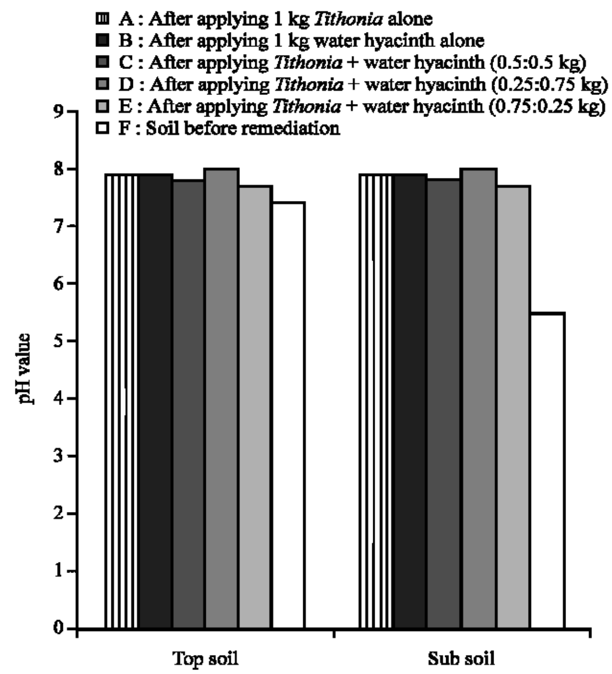

Fig. 1: Soil pH of unamended and amended top and sub soils

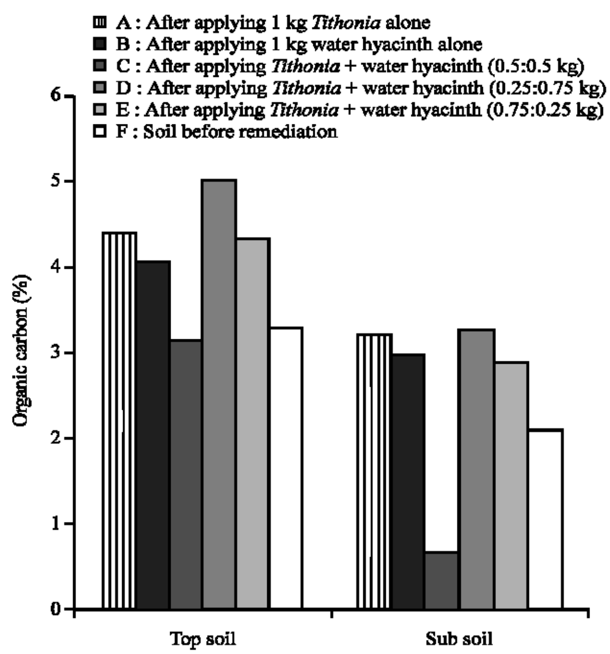

Fig. 2: Percentage organic carbon for unamended and amended top and sub soils

treatments when compared with control treatment (that is, soil before remediation with amendments). However, treatment with water hyacinth compost in sole application accounted for highest input with respect to percentage nitrogen content for both soil types.

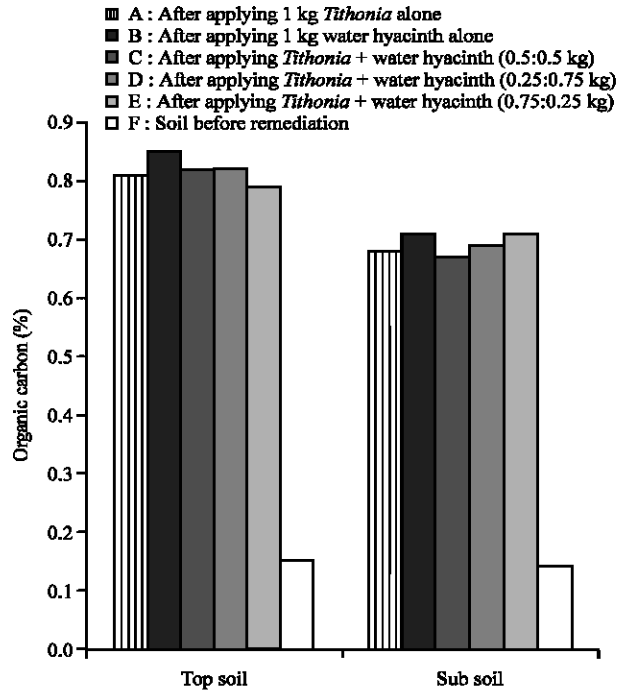

Fig. 3: Percentage nitrogen for unamended and amended top and sub soils

DISCUSSION

The application of *Tithonia* Green Manure (TGM) and Water Hyacinth Compost (WHC) markedly changed soil chemical properties. Soil pH was increased by at least 30% in the amended/treated soils for top and subsoil samples compared to the control treatment. The highest soil pH was recorded for WHC plus TGM treatment in the proportion of 3 parts water hyacinth compost to 1 part TGM (that is, 0.75:0.25 kg, respectively) in the top soil sample. On the other hand, highest soil pH change was recorded for subsoil sample in the WHC mixed with TGM treatment in the ratio 1 to 3, respectively. There appears to be a general pH change towards alkalinity in treated soils induced by addition of organic amendments for both soil sample types, but more pronounced in the subsoil sample. This is significant because acidic ultisols and oxisols which occur usually in upland soils of the humid forest zone in the tropics are reported to contain very low levels of mineral nutrients (Hossner and Anthony, 1999).

WHC and TGM in both sole and combination applications generally show a trend of increasing amount of nutrients in both top and sub soil samples. Exchangeable elements Ca, Mg, K and Na as well as micronutrients Mn, Zn and Cu were increased in all treatment combinations as well as sole applications of either water hyacinth compost and/or *Tithonia* green manure. Highest Effective Cation Exchange Capacity (ECEC) values occurred in the compost plus green manure treatment (0.75:0.25 kg) while lowest ECEC was recorded in the control. Increase in Cation Exchange Capacity (CEC) in soils treated with organic amendments indicates a higher level of exchangeable cations in the soil, which in turn indicates an increased level of soil nutrients that would be available for plant use and development (and hence, increased soil fertility).

Highest available P was recorded in the treatment containing WHC plus TGM in the ratio 1 to 1 (0.5:0.5 kg) in the sub soil sample and highest P was recorded for sub soil sample in the sole compost treatment in the top soil sample. Available P contents were markedly higher than P content in the control treatment. This may have resulted due to change in soil pH, wherein fixation of phosphate by Al and Fe is decreased and P is more readily available in treated soil samples compared to available P in control treatment.

In general, the application of the organic amendments in sole and varying combined rates caused a buildup in total available elements in soils thus enhanced the soil fertility status for amended soils as compared to natural fallow soil.

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